MONTHLY WEATHER REVIEW.

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INTRODUCTION.

This REVIEW for September, 1893, is based on reports from 3,021 regular and voluntary observers. These reports are classified as follows: 160 reports from Weather Bureau stations; 40 reports from United States Army post surgeons; 2,016 monthly reports from state weather service and voluntary observers; 60 lake marine reports from navigators on the Great Lakes; 32 reports from Canadian stations; 222 reports through the Southern Pacific Railway Company; 491 marine reports through the co-operation of the Hydrographic Office, Navy Department; marine reports through the "New York Herald Weather Service"; monthly reports from local services established in all states and territories; and international simultaneous observations. Trustworthy newspaper extracts and special reports have also been used.

The WEATHER REVIEW for this month has been prepared under the general editorial supervision of Prof. Cleveland Abbe.

CHARACTERISTICS OF THE WEATHER FOR SEPTEMBER, 1893.

TEMPERATURE.

The month was warmer than normal throughout the interior of the country and especially in the Northwest and Southwest; the temperature was below the normal on the Pacific coast. It was the warmest September on record at Columbia, S. C., Springfield, Mo., Topeka, Wichita, and Dodge City, Kans., Abilene, San Antonio, and Corpus Christi, Tex. It was the coldest September at Portland, Me., Northfield, Vt., Oswego, N. Y., Nantucket, Mass., Narragansett Pier, R. I., Fort Canby, Wash., Roseburg, Oregon, Winnemucca and Carson City, Nev., and Fresno and Keeler, Cal.

PRECIPITATION.

The rainfall was in excess in Maine, the interior of North Carolina, northern Georgia, western Tennessee and Kentucky, southeastern Louisiana, and southwestern Alabama. The rains in Greene County, Va., from the 9th to 18th were the heaviest known for 70 years.

DROUGHT.

A protracted drought prevailed over all sections of Nebraska from the 1st to the 26th of September. On the latter date light rains were general in the southeastern portion of the state, and a few scattered showers fell in the central section. On the 29th the drought was thoroughly broken, all sections experiencing refreshing showers. The rains were uniformly heavy in all sections except the west and northwest, where only light showers, ranging from trace to 0.20 of an inch, were reported. In Ohio the drought was reported as damaging pastures and crops.

LOCAL WINDSTORMS.

The local windstorms of September have been almost exclusively so-called thunderstorms and squalls. The principal exceptions were the severe gales that passed over Chicago, Lake Michigan, and Lake Huron on the 21st; the highest wind on record at Marquette occurred this day (61 miles per hour). The only tornado reported occurred on the 7th, at Lockport, La., in connection with the hurricane that was at that time passing northward through that state.

HOT WINDS.

A hot wind extended north and south through portions of Kansas, Oklahoma, and Texas on the afternoon of the 13th. At Oklahoma this hot wind was first felt about 1 p. m. and continued until sundown, when the weather grew gradually cooler. The maximum temperatures of the month in all this portion of the country frequently exceeded 100°, and occurred in connection with this hot wind.

HAIL.

Hailstones a half-inch in diameter fell at Virginia City, Nev., about 5 p. m. of the 6th. It is reported that a hailstone 9¼ inches long was found on the 7th in Bath, N. Y.; the attending storm was remarkable for the darkness.

FOREST FIRES.

Great damage and dense smoke were caused by forest fires throughout the latter half of the month in Wisconsin. Navigation on Lake Michigan was sometimes interfered with.

HURRICANES.

The only hurricane that entered the United States was that which passed from the Gulf of Mexico northeastward into Louisiana on the 7th; it was entirely dissipated before it reached Tennessee. Only one hurricane appears to have passed over the western portion of the Atlantic Ocean; it did not affect the United States, and its track was quite uncertain.

SNOWFALL.

Heavy snowfall has been reported at a few stations in Colorado, Nevada, and Montana.

ATMOSPHERIC PRESSURE (expressed in inches and hundredths).

The distribution of mean atmospheric pressure for September, 1893, as determined from observations taken daily at 8 a. m. and 8 p. m. (75th meridian time), is shown on Chart II by isobars.

Chart V exhibits the normal distribution of atmospheric pressure and normal wind movement by Lambert's formula over the United States for September, and has been prepared by Prof. H. A. Hazen, who has also prepared all the others of

this series, preliminary to the publication by the Weather Bureau of specially prepared data and charts showing the meteorological and climatic features and conditions of the United States. The pressures for both Canada and the United States are reduced to sea-level by Prof. Hazen's methods and formulæ.

As compared with the preceding month of August, the mean pressures for September, 1893, are higher throughout the Gulf and Atlantic states, the maximum being +0.10 in North and South Carolina; they are also slightly higher in California; pressures are lower on the east Rocky Mountain slope in Washington and British Columbia.

As compared with the normal for this month the pressures for September, 1893, have been generally low throughout the United States, the maximum deficit being from 0.10 to 0.13 in the Dakotas and Manitoba; pressures have been slightly above the normal in southern Florida and the immediate coast of the south Atlantic states.

HIGH AND LOW AREAS.

The paths of the centers of high and low areas moving over the United States and Canada during September, 1893, are traced on Charts IV and I, respectively, and their principal characteristics are given in the following text and tables:

HIGH AREAS.

I.—This designates a rise of pressure that appeared off the east Atlantic coast while "low" number I was moving down the Saint Lawrence Valley. It may, of course, be considered as a northwestern extension of the tropical area of high pressure over the Atlantic Ocean; it may also be considered as due to the accumulation of air drawn from the Atlantic "high" toward the "low" that was central in Canada but hindered in its flow thither by the resistance due to land and mountains. Still another plausible way of looking at the formation of the "highs" in connection with "lows" is the following: The map of the morning of September 1st shows a low pressure in the Gulf of Mexico and another between Hudson Bay and Lake Superior, while a "high" lay east of the middle Atlantic coast and a more decided "high" extended from Texas to Saskatchewan; now, if we look upon areas of low pressure as being filled with warm, moist air whose buoyancy causes an updraught and consequently an inflow from all sides with a corresponding overflow in the upper region, then the areas of high pressure where this overflow descends would correspond to portions of the so-called pericyclone and might be said to owe their existence to the presence of the low pressure. But this, which is possibly true for small cyclonic areas, can scarcely apply to regions that extend north and south 30° in latitude or east and west 30° or more in longitude. In these latter cases the comparatively thin layer of atmosphere, twenty miles in depth but fifty or a hundred times as much in horizontal extent, can not be considered as having a simple rotary motion; on the contrary, its motions are principally a horizontal flow and a slow vertical rise or fall. The upper layers move with comparative freedom over the lower ones, but the latter are much affected by the resistance due to the irregularities of the earth's surface. The general circulation of the atmosphere between the equator and the poles sends the upper layers of the atmosphere north or northeastward from N. 10° to N. 30°, or 60°, within which latter limits this air must descend to the earth's surface, and when it reaches the ground it spreads out in all directions, forming the so-called "highs." Two such "highs" must be separated by a region in which the upper layers do not so easily descend to the earth's surface, and as their surface winds blow toward each other they must set the intervening air into a system of cyclonic rotation. From this point of view the "lows" are a necessary consequence of the "highs" and owe their existence ultimately to the general circulation of the atmosphere. This latter is undoubtedly a very common condition on the earth's surface. The exact location and the details of the tracks of the centers of high and low pressure must depend on the distribution of oceans, continents, mountains, and table-lands, and may therefore be quite irregular, but the existence of the "highs" and "lows," or the cyclones and anticyclones, and the general average direction of their paths would be the same if there were no irregular resistances. In a perfectly dry atmosphere the duration of any given area of low pressure would be less than we at present observe it, but in a moist atmosphere the formation of cloud and rain, the evolution of latent heat, and the interception of solar heat by the clouds conspire to prolong the life of an area of low pressure and to intensify the speed of its winds and to deepen the depression of the central low pressure. In this way moisture may become the most important feature in the mechanism of a low area. In this interaction of areas of high pressure and low pressure it becomes improper to speak of either exclusively as the cause of the other, and if such expressions are used, they must be accepted with limitations.

In its progress eastward the central point of highest pressure does not necessarily coincide with the calm region about which the anticyclonic winds are conceived to circulate, and neither of these centers of pressure or calm coincide exactly with the region of lowest abnormal temperature or with the region of clearest blue sky and greatest radiation from the earth's surface. Frequently several local centers of pressure and wind appear to be included within the region of highest pressure, but they can not be properly located until more satisfactory methods of reduction to sea level and standard gravity have been devised.

II.—Was central on the morning of the 1st from Colorado to Assiniboia and moved southeastward until on the 7th, in the morning, it was east of the south Atlantic coast. During this interval this area covered a large part of the United States with clear, cold weather; frost was reported on its northern border on the morning of the 2d north of Lake Superior.

III.—Appeared on the morning of the 5th north of Lake Superior, and moving southeastward was off the Atlantic coast on the morning of the 7th.

IV.—Was north of Lake Superior on the morning of the 7th, and moving southeastward was central in eastern New York on the morning of the 9th.

V.—Descended from Labrador over the Saint Lawrence Valley on the 10th, to the southern coast of New England on the 12th, whence it slowly moved eastward and was on the 15th off Nova Scotia.

VI.—Appeared on the 12th west of British Columbia and, moving eastward, was on the 14th in the State of Washington, but on the 15th had crossed the Rocky Mountains into Alberta and Assiniboia, thence it moved rapidly southeast over Nebrasks, Illinois, and western Kentucky, and was on the 18th on the south Atlantic coast. It disappeared in Alabama on the 19th.

VII.—Appeared on the 17th in British Columbia and Alberta, moved south into Montana on the 18th, eastward to the north of Lake Superior on the 20th, southeast over New York on the 21st, and southward along the Atlantic coast, disappearing on the 22d.

VIII.—Appeared on the 20th west of Oregon, moved northwest into Washington on the 22d, was central in South Dakota on the 23d in the morning, at which time, also, barometric depressions were forming over Texas and New Mexico, as also over the upper lakes. A center of high pressure appeared on the morning of the 24th in Alberta, but so intimately connected with that which had moved into Dakota that they must be considered as portions of a larger region.

Number VIII continued moving southeastward to Virginia on the 24th and disappeared on the 25th east of New England.

IX.—Appeared on the 24th in Alberta, and on the morning of the 25th was central in Nebraska. Heavy frosts prevailed in Iowa and Wisconsin; light frosts in Missouri, Kansas, and Illinois. It was central on the 26th in Ohio; light frosts prevailed in Missouri, Illinois, Indiana, Michigan, Ohio, and western New York. It disappeared on the morning of the 27th in Pennsylvania, at which time high pressure prevailed throughout the United States, except in Arizona, southern California, Utah, and Nevada.

Movements of areas of high and low pressures.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
High areas.		°	°		°	°	*Miles.*	*Days.*	*Miles.*	*Miles.*
I	1, a. m.	39	68	1, p. m.	42	64	250	0.5	.....	.....
II	1, a. m.	52	107	6, a. m.	33	78	2,550	5.0	510	21.2
III	5, a. m.	50	87	7, a. m.	37	73	1,200	2.0	600	25.0
IV	7, a. m.	51	90	9, a. m.	42	74	1,100	2.0	550	23.1
V	10, a. m.	50	67	15, p. m.	43	62	1,600	5.5	291	12.1
VI	12, a. m.	47	130	19, p. m.	33	87	3,900	7.5	520	21.7
VII	17, a. m.	52	117	22, p. m.	29	74	3,550	5.5	646	26.9
VIII	20, a. m.	42	127	25, a. m.	41	64	3,600	5.0	720	30.0
Mean	.....	.....	.....	.....	.....	.....	.....	.....	548	22.8
Low areas.										
I	31, p. m.	48	91	4, a. m.	51	57	1,650	3.5	472	19.6
II	1, a. m.	28	87	1, p. m.	?	?	.....	0.5	.....	.....
III	1, a. m.	50	130	4, a. m.	48	87	1,900	3.0	633	26.4
IV	4, p. m.	51	116	8, a. m.	47	58	3,050	3.5	871	36.3
V	6, p. m.	52	115	9, p. m.	53	106	550	3.0	183	7.6
VI	6, a. m.	27	93	11, p. m.	37	88	1,200	5.5	218	9.1
VII	10, a. m.	54	112	21, p. m.	47	54	4,550	11.5	396	14.5
VIII	15, p. m.	54	117	19, a. m.	47	85	2,200	3.5	629	26.2
IX	19, a. m.	49	126	22, p. m.	50	69	2,900	3.5	829	34.5
X	22, p. m.	52	89	26, a. m.	49	54	1,600	3.5	458	19.1
XI	27, a. m.	53	125	29, a. m.	56	108	800	2.0	400	14.4
XII	29, a. m.	35?	60?	30, p. m.	43?	60?	650?	1.5	.....	.....
XIII	27, p. m.	35	114	30, p. m.	40	97	1,500	3.0	500	20.8
Mean	.....	.....	.....	.....	.....	.....	.....	.....	508	21.2

LOW AREAS.

I.—Appeared on the 31st north of Lake Superior, and is the same as number XIII of the August REVIEW. It passed nearly due eastward through Ontario and Quebec, and disappeared on the 4th in the northern portion of the Gulf of Saint Lawrence.

II.—Appeared as an indefinite area of low pressure in the northern portion of the Gulf of Mexico on the morning of the 1st, but had disappeared by the morning of the 2d.

III.—Appeared west of British Columbia on the morning of the 1st, and was central in Saskatchewan on the afternoon of the 2d, whence it moved southeast, reaching Lake Superior on the morning of the 4th, where it disappeared. Probably the course of the central low was far north of our stations.

IV.—Appeared on the 4th in British Columbia, moved east into Assiniboia on the 5th, thence southeast over the Dakotas into Wisconsin and Iowa on the 6th, thence east-northeast over the Lake region, New England, and Nova Scotia, disappearing on the 8th near Newfoundland.

V.—Appeared on the 6th in Alberta, moved slowly southeast and then northeast during the 7th, 8th, and 9th, and then west until on the 10th it was again in Alberta, then moved southerly and joined area number VII, and on the morning of the 11th passed into Assiniboia. During this day it stretched as a very long oval from Utah to Saskatchewan, with apparently two centers of rotation of wind; these were united on the morning of the 10th, but during that day it again became an elongated oval, and on the 13th, 8 a. m., it presented three centers of low pressure in Nebraska, South Dakota, and Manitoba, respectively, but by 8 p. m. of the 13th only one of these remained (in northwestern Iowa), which then moved northeastward over Lake Superior and thence eastward, reaching the Saint Lawrence on the 17th, thence northeast, reaching Labrador on the 18th, and thence southeast over Newfoundland, disappearing on the 21st.

VI.—This storm in the Gulf of Mexico evidently existed on the morning of the 5th, at which time pressure was diminishing at distant stations on the Gulf coast, but no marine reports are at hand to locate the center more exactly. The increasing northeast winds on the coast of Louisiana and Texas showed that a hurricane was moving northward on the 6th. During Thursday, 7th, the center moved northward over the southeastern portion of Louisiana, doing much damage over a small area, but rapidly breaking up as it moved inland. The course of the center was quite irregular. On the afternoon of the 8th it was central in southeastern Alabama, and the area of revolving winds with rain continued to remain south of Tennessee until the 11th, by which time pressure had become nearly normal and the storm-center had disappeared.

VII.—Was central on the 10th in Alberta, moved southward, and on the 11th was represented by two centers, in Utah and Assiniboia, respectively. On the 12th, in the morning, there was but one center (in Montana), but on the afternoon of the 12th again two centers in Assiniboia and Colorado, respectively. On the 13th, in the morning, this had become three centers, in Montana, South Dakota, and Nebraska, which had again all united on the afternoon of the 13th in northwestern Iowa.

VIII.—Was central in British Columbia on the 15th, Alberta on the 16th, and Manitoba on the 17th; thence suddenly moved south into Iowa on the 18th; thence northeast over Lake Superior on the 19th, where it disappeared.

IX.—Central on the 19th west of British Columbia; moved southeast into Idaho, thence east over North Dakota, being central in northwestern Minnesota on the 21st, in the morning. At this time a new depression appeared in northern Texas, it moved east and disappeared on the 22d as a branch of number IX in Indian Territory. The main low center moved east over Lake Superior, thence northeast, keeping north of the Saint Lawrence Valley, and also disappeared on the 22d.

X.—On the 22d, in the afternoon, an extensive area of low pressure prevailed north of Minnesota, moved slowly eastward, and on the 25th was central northeast of Lake Huron, after which it moved rapidly northeast, and on the 26th disappeared over Newfoundland.

XI.—Was central on the 27th in British Columbia, passed east into Alberta and northeast through Saskatchewan, disappearing on the 29th in that region.

XII.—The early history of this storm is not yet known to us; it was probably a severe storm on the 29th, and central in the morning at about N. 35° and W. 60°, moving northwestward; it soon recurved, and on the 30th moved northeastward over the Grand Banks toward Cape Race.

XIII.—By this number I designate the extensive area of low pressure that persistently develops throughout the summer season at the head of the Gulf of California. Stations are not sufficiently close together to locate the ever varying extent of this low pressure. Its existence and changes evidently do not depend upon local temperatures or winds; it is analogous to the depression over India, and is a part of the general system of circulation of the atmosphere over the eastern Pacific Ocean taken in connection with the presence of the Coast Range, the Rocky Mountains, and the Cordilleras. Occasionally this region increases in size and sends a small special area of low pressure with accompanying whirl of wind off to the eastward. Such an expansion took place on

the 25th, 26th, and 27th, while at the same time an area of low pressure stretched southward over British Columbia and Alberta; on the 28th these two depressions, central respectively at Yuma and Edmonton, appear to have been only parts of a still greater feature in the general circulation of the atmosphere. On the morning of the 29th the southern end of this depression was represented by a "low" in Kansas and the northern end by a "low" in Saskatchewan; this latter is the depression (XI) just alluded to as central in British Columbia on the 27th, whence it passed over into Alberta on the 28th, and was in Saskatchewan on the 29th. On the 30th these were united in a large area whose center was in Nebraska while a new depression was forming in the Gulf of California.

NORTH ATLANTIC STORMS FOR SEPTEMBER, 1893.

[*Pressure in inches and millimeters; wind-force by Beaufort scale.*]

The paths of storms that passed over the western portion of the north Atlantic Ocean are shown on Chart I, so far as can be traced from information received up to the 25th of October, through the co-operation of the Hydrographic Office and the "New York Herald Weather Service."

The normal pressure for September over the north Atlantic Ocean, as shown by the international simultaneous meteorological observations, is highest, 30.18 (767), in a small oval between parallels N. 33° and N. 39° and meridians W. 22° and W. 38°. The isobar of 30.10 (764) extends from W. 11° to W. 86° and between the parallels N. 23° and N. 43°. Pressure is lowest, 29.70 (754), from N. 58°, W. 25° northward over Iceland, Greenland, and Nova Zembla. As compared with August the normal pressure for September is 0.05 less in the mid-Atlantic over a narrow belt extending from N. 20°, W. 65° to N. 35°, W. 38°.

The tracks of storms for September may be classified as: (I) those that pass from the equatorial Atlantic westward over the West Indies and the Caribbean Sea to the Gulf of Mexico, or at least to Florida, and then recurve toward the northeast, passing over the Atlantic States and Labrador into the north Atlantic region; (II) those that start in the equatorial Atlantic and after passing a short distance northwest recurve to the northeast long before reaching the West Indies or the American coast; these also finally enter the north Atlantic region; (III) those that pass from Bering Sea and the northwest Pacific eastward over the Rocky Mountains and southeastward over the Great Lakes region, thence eastward to the Atlantic Ocean.

The average velocity of movement of storm centers for September, in statute miles per hour, is 26 for the United States when moving westward, and 19 for the Atlantic Ocean. During the process of recurving the West Indian hurricanes move at the rate of only 9 miles per hour. On the average about one storm endures long enough to pass from the North American continent over the Atlantic to Europe.

During September, 1893, the following storms have been traced over portions of the north Atlantic Ocean; the centers are located for Greenwich noon by international simultaneous observations as follows:

A. A low barometer existed northeast of Labrador September 1st, 29.20 being reported at N. 54° and W. 50°, with westerly gales southward to N. 40°. This was undoubtedly the end of the hurricane described in the August REVIEW. It moved slowly eastward, being apparently in W. 40° on the 2d, after which it disappeared from our chart and merged into the general low pressure around Iceland.

B. A low barometer northeast of Labrador on September 5th, with westerly gales to the southward, apparently a continuation of the September low area No. 1. This moved northeast and expanded rapidly into the Icelandic low area, which, on the 7th, was central to the east of Iceland, while severe northwest gales prevailed between N. 45° and 55°, and W. 45° and 55°. On the 8th the low was central over the north Baltic, whence it moved southeastward into Russia.

C. On the 5th the pressure was diminishing at the Isthmus of Panama, and on the 6th in western Cuba, at which time a hurricane center probably existed in the western portion of the Gulf of Mexico. The track of this hurricane is not satisfactorily shown by the marine reports, but it is undoubtedly the same that passed northeastward along the coast of Louisiana until it entered and crossed that state on the 7th and 8th.

D. On the 9th a storm-center passed over the Gulf of Saint Lawrence, and on the 10th was apparently east of Labrador. No further details can be given as to the center of this area of low pressure until on the 13th, when it was apparently east of Iceland.

E. On the 11th a storm-center was apparently central at N. 43°, W. 54°. On the 12th it was at N. 48°, W. 42°. On the 13th, N. 54°, W. 40°, after which it can not be traced, but by the 15th the isobars of the preceding low over the Baltic had stretched westward as though the present low was about to join that one, and on the 16th pressure was again lowest over the Baltic. On the 17th, and thence until the 22d, low pressure was again lowest over the Baltic. On the 17th, and thence until the 22d, low pressure covered the whole of Europe, sometimes presenting several subsidiary low centers. On the 23d pressure rose in southeastern Europe and the principal low center was over Norway. On the 24th and 25th the pressure continued rising in southeastern and southwestern Europe, continuing lowest over Norway and Sweden. On the 26th and 27th pressure slowly recovered, and the low center disappeared in the presence of a still deeper low advancing from the Atlantic.

F. From the 14th to 17th pressure steadily rose in the mid-Atlantic and eastward to Africa and northward to N. 55°. Apparently the low area was passing eastward on or north of N. 60°, and on the 19th low pressure was central east of Iceland, while northwest gales prevailed north of N. 50° and east of W. 30°. This, combining with the low from which Europe was then recovering, caused the low pressure to continue prevailing over Europe until the 28th, as above mentioned. The center of lowest pressure was generally over Norway and Sweden. On the 27th a single report, 29.46, force 11, at N. 54°, W. 46°, shows that a third low center was advancing southeastward from Baffins Bay. On the 28th this was apparently in W. 20°, and on the 29th was near the coast of Scotland, having grown steadily in the extent of its depression. Pressure again fell throughout Europe, while this depression moved northeastward, and on the 30th was central north of the coast of Scotland.

OCEAN FOG IN SEPTEMBER.

The limits of fog belts west of the 40th meridian, as reported by shipmasters, are shown on Chart I by dotted shad-